

Appl. No. : 10/007,304
Filed : December 5, 2001

AMENDMENTS TO THE CLAIMS

Please cancel Claims 35, 52 and 55.

Please amend Claims 36, 37, 39-41, 43, 45, 47-49, 53, 54, 56 and 57 as indicated below.

1. - 35. (CANCELLED)

36. (CURRENTLY AMENDED) The diffusion barrier of Claim 49[[35]], wherein the metal nitride of the first metal nitride layer is selected from the group consisting of titanium nitride, tungsten nitride and tantalum nitride.

37. (CURRENTLY AMENDED) The diffusion barrier of Claim 36, wherein the metal nitride of the first metal nitride layer is titanium nitride.

38. (CANCELLED)

39. (CURRENTLY AMENDED) The diffusion barrier of Claim 49[[35]], wherein the reactive metal is Al.

40. (CURRENTLY AMENDED) The diffusion barrier of Claim 49[[35]], wherein the reactive metal is Si.

41. (CURRENTLY AMENDED) The diffusion barrier of Claim 49[[35]], wherein the reactive metal is a lanthanide.

42. (CANCELLED)

43. (CURRENTLY AMENDED) The diffusion barrier of Claim 49[[35]], wherein the metal compound is an oxide of the reactive metal.

44. (PREVIOUSLY PRESENTED) The diffusion barrier of Claim 43, wherein the metal compound is selected from the group consisting of aluminum oxide and silicon oxide.

45. (CURRENTLY AMENDED) The diffusion barrier of Claim 49[[35]], wherein the metal compound is a nitride of the reactive metal.

46. (PREVIOUSLY PRESENTED) The diffusion barrier of Claim 45, wherein the metal compound is selected from the group consisting of aluminum nitride and silicon nitride.

47. (CURRENTLY AMENDED) The diffusion barrier of Claim 49[[35]], wherein the first metal nitride layer is about 5 to 10 nm thick.

48. (CURRENTLY AMENDED) The diffusion barrier of Claim 49[[35]], wherein the reactive metal layer is about 2 nm thick.

49. (CURRENTLY AMENDED) A diffusion barrier for a copper interconnect comprising a first layer of metal nitride directly contacting and covered by a layer of reactive

metal, and The diffusion barrier of Claim 35, additionally comprising a second layer of metal nitride directly contacting and over the layer of reactive metal, wherein the grain boundaries of the first and second metal nitride layers are stuffed with a metal compound of the reactive metal, wherein the reactive metal is a different metal from each metal in the metal nitride layers and is selected from the group consisting of Al, Si, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mg, Y and La, and wherein the diffusion barrier directly underlies a copper layer of the copper interconnect.

50. (PREVIOUSLY PRESENTED) A diffusion barrier for a copper interconnect comprising:

a first layer of metal nitride;

a layer of reactive metal directly contacting and over the first layer of metal nitride wherein the reactive metal is selected from the group consisting of metals of group IIIB of the periodic table, metals of group IVB of the periodic table, metals of group VB of the periodic table and metals of group VIB of the periodic table; and

a second layer of metal nitride directly contacting and over the layer of reactive metal, wherein the grain boundaries of the first and second metal nitride layers are stuffed with a compound of a metal different from the metal in the nitride layers and the second layer of metal nitride underlies and contacts a copper layer of the copper interconnect.

51. (PREVIOUSLY PRESENTED) The diffusion barrier of Claim 50, wherein the compound of a metal different from the metal in the nitride layers is selected from the group consisting of an oxide of the reactive metal and a nitride of the reactive metal.

52. (CANCELLED)

53. (CURRENTLY AMENDED) The diffusion barrier of Claim 54[[52]], wherein the first layer of titanium nitride is deposited by atomic layer deposition (ALD).

54. (CURRENTLY AMENDED) A diffusion barrier for a copper interconnect that directly contacts and underlies a copper filler of the copper interconnect, the diffusion barrier comprising a first layer of titanium nitride directly contacting and covered by a layer of aluminum and ~~The diffusion barrier of Claim 52, additionally comprising a second layer of titanium nitride between the aluminum layer and the copper filler, wherein the grain boundaries of the first titanium nitride layer are stuffed with aluminum oxide.~~

55. (CANCELLED)

56. (CURRENTLY AMENDED) The diffusion barrier of Claim 57[[55]], wherein the layer of metal nitride comprises titanium nitride.

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57. (CURRENTLY AMENDED) ~~The diffusion barrier of Claim 55,~~
~~additionally comprising~~ A diffusion barrier for a copper interconnect comprising a layer of metal
nitride directly contacting and covered by a layer of silicon and a second layer of metal nitride
directly contacting and over the layer of silicon, wherein the grain boundaries of the metal nitride
layer are stuffed with silicon oxide and the diffusion barrier directly underlies a copper layer of
the copper interconnect.

58. (ORIGINAL) The diffusion barrier of Claim 57, wherein the second layer of metal nitride comprises titanium nitride.